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Biofuel implementation in East Europe: Current status and future prospects

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Abstract

There is a continuously increasing interest concerning the biofuel implementation in Europe, mainly because of environmental protection and energy supply security reasons. In this context, the European Union (EU) strongly encourages the use of biofuels through a number of Directives. To that effect, EU members follow the Directives implementing various political, fiscal and technical measures and incentives. In the light of the potential created by the recently joined Eastern European countries, an increasing interest is shown in the whole biofuel supply chain within the EU. In parallel, the status of the Eastern European countries domestic market, as far as biofuels are concerned, is an interesting issue, since most of these countries present a significant potential, however still lagging in biofuel implementation. In the above context, the objective of the present work is to give a concise and up-to-date picture of the present status of biofuel implementation in East Europe. The work also aims at identifying the prospects of these countries as far as biofuels are concerned and their role in the EU framework as potential suppliers of a wider market.
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Keywords: Biodiesel; Bioethanol; Eastern Europe; Biofuel supply chain

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Contents

1. Introduction

Continuous efforts towards the solution of the energy supply security problem and the environmental impacts caused by the transportation sector have led to the development of the so-called alternative fuels through extensive research activities. Liquid biofuels, produced from biomass such as agricultural crops, wood and food-processing residues, can be used as transportation fuels in a large range of vehicles and offer the potential for development towards sustainable mobility with the involvement of the agricultural, energy and automotive sectors.

Various research works have been carried out concerning technical, political and economic issues of the production, promotion and implementation of biofuels in Europe. Critical issues that are examined by research works are the resources potential in the European Union (EU) [1,2], technological and economic performance and potential of various biofuels [3], and evaluation of biofuel production technologies [4–6]. Furthermore, the enlargement of the EU by countries of Central and Eastern Europe provide some more opportunities for biodiesel and bioethanol production [7], as those countries have presently double the acreage per citizen compared to the EU-15 and have a significant potential in agro-productivity.

Various opinions have been expressed concerning the possible contribution of the Eastern European countries in the overall biofuel supply chain in the EU [8–10]. However, there is a lack of an integrated review of their biofuel potential, including quantitative information, mainly because of the lack of uniform and reliable information from these countries.

In any case, a detailed study that has recently been carried out [8] supports the idea that the potential contribution of Eastern European countries to the enlarged European production is not sufficient to cover its fair shares of the overall enlarged EU biofuel supply.

Yet, the implementation of biofuels in Eastern Europe is an interesting issue, since these countries have a significant biofuel potential, either in the raw materials or in the biofuel production [10].

Therefore, the objective of the present work is to give a concise and up-to-date picture of the current status of biofuel implementation in Eastern Europe. The work also aims at identifying the prospects of these countries as far as biofuels are concerned, and their role in the overall biofuel supply chain in the EU.

2. Eastern European countries as members of the EU

The EU is a cohesion of independent countries. Out of its successive enlargements, by far the biggest happened on 1 May 2004, when 10 countries joined the Union. These countries are Czech Republic, Cyprus, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia. Bulgaria and Romania are likely to become members of the EU in 2007. After joining, new members must abide by the same EU laws and rules that apply to the old members.

As mentioned above, the Eastern European countries that have recently joined the EU have a special interest as far as biofuels are concerned, mainly because of their land availability and agricultural and production experience and tradition. Table 1 includes the basic information concerning the 10 accession and the two candidate countries [11].

The present work has focused on some of the above countries and, more specifically, on those that show a considerable progress or potential in one or more of the biofuel supply chain components. The countries that are considered in more detail in the present work are Czech Republic, Hungary, Lithuania, Poland, Bulgaria and Romania.

The final energy consumption for transportation purposes actually gives an indication of the biofuel quantity that will be required in the future years. Fig. 1 shows the final energy consumption for transportation purposes for the EU-15 and the new Eastern European EU members.

3. Biofuel value chain

The introduction, development and promotion of biofuels in the EU countries are interesting issues with at least two basic components and objectives:

- The primary objective pertains to the achievement of the reference targets set forth by the Directive 2003/30/EC through the substitution of the petrol and diesel consumption by biofuels and/or other renewable fuels.

Table 1
Basic data concerning the new EU members

Country	Total area (sq. km)	Population (million) (2005)	GDP (thousand M€) (2000)	Energy demand in transport (Mtoe) (2005)
Czech Republic	78,864	10.31	73.7	5.48
Cyprus	9251	0.78	11.7	0.98
Estonia	45,226	1.475	7.5	0.75
Hungary	93,033	10.201	68.2	3.99
Latvia	6461	2.52	10.5	0.85
Lithuania	65,200	3.71	16.0	1.29
Malta	316	0.37	4.7	0.34
Poland	312,685	38.73	224.8	10.27
Slovakia	48,845	5.372	26.7	1.73
Slovenia	20,253	1.98	24.3	1.53
Bulgaria	110,912	7.78	18.4	2.19
Romania	238,391	22.67	53.6	4.69

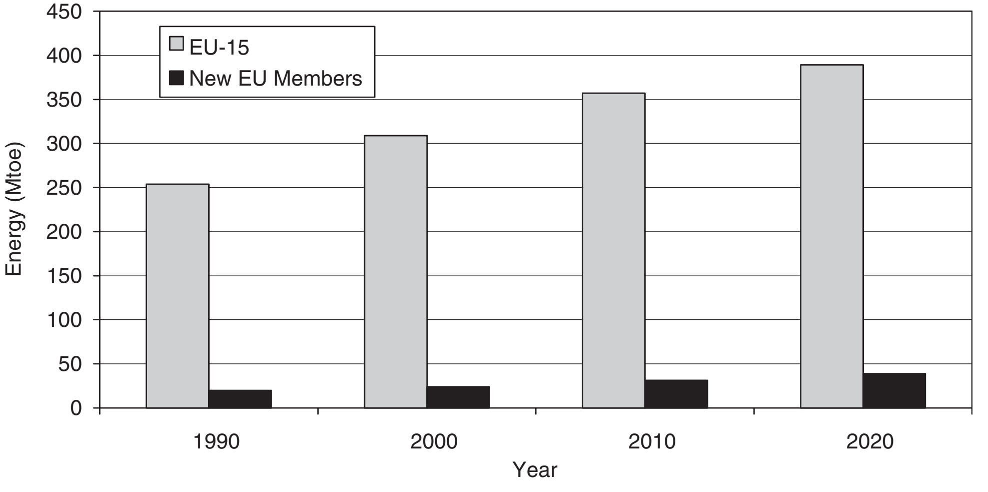


Fig. 1. Final energy consumption for transportation in the EU-15 and in the new EU members [11].

- The other objective relates to the prospects that are created for the national economy of the involved countries by promoting the development of domestic feedstock and biofuel production.

Certainly the first objective is an obligation and each EU member country member seeks for the most efficient and successful strategy for its achievement. The accomplishment of the primary objective does not necessarily require that feedstock or even biofuel production should be domestic. Certainly, for many countries in the EU, the target values will be reached only by biofuel imports.

The second objective is related to decisions concerning the development of the biofuel supply chain. Many countries consider biofuel implementation as an important opportunity for the development of their agriculture, production infrastructure and energy supply basis, and this is also an EU concern.

In the general case, the value chain for biofuels includes the following activities (Fig. 2):

- feedstock production (related to land availability and agriculture),
- biofuel production (transformation of feedstock into biofuel),
- blending (if biofuels are blended in fossil fuels),
- distribution (fuel distribution chain) and, finally,
- consumption.

Definitely, the development of domestic biofuel production does not necessarily mean that all feedstock used should be of domestic origin. Indeed, part or whole of the feedstock or biofuels could be imported. Finally, some countries may produce feedstock and biofuels and export them, in case there is a surplus for their internal consumption.

The decision on the point of entry into the biofuel value chain raises the question of whether a country is able (technically, economically, etc.) to produce and/or import

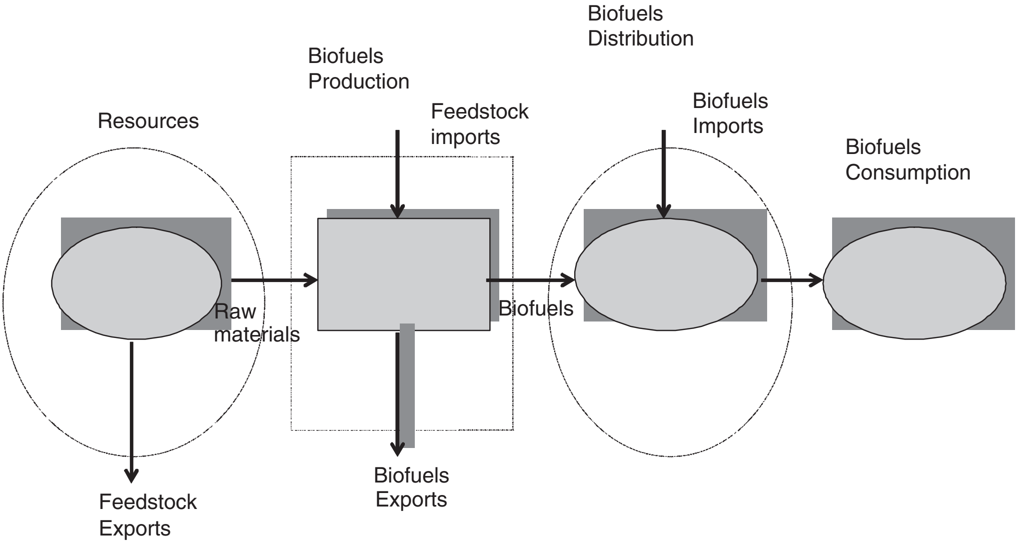


Fig. 2. Biofuels supply chain structure.

feedstock and/or biofuels. This poses questions such as whether each country intends to encourage capacity building or cover the required quantities via imports.

On the other hand, considering the EU as an integrated market, it is critical to identify the role of each member in the biofuel supply chain. Depending on the land availability and suitability, the production expertise and the domestic market development, some countries will rather serve only as raw material producers, others as biofuel producers and others will combine a more complex role.

4. Land availability—feedstock production

Biodiesel is produced from vegetable oils, which are derived from the seeds or the pulp of a range of oil-bearing crops. These oil crops can be annual (rapeseed, sunflower, groundnut and soybean) or perennials (oil palms, coconut palms, physical nut and Chinese tallow tree). Oil from the rapeseed was the first type used for biodiesel production. Today, in Europe, rapeseed is still the main feedstock for biodiesel production. It is grown throughout Europe, while sunflower seed crops are grown only in the warmer areas.

In Europe, the main crops for the production of bioethanol are starch crops (such as common wheat) and sugar beet. Sugar beet crops are grown in most of the EU-25 countries, and yield substantially more ethanol per hectare than wheat.

The 10 new member states bring with them 8% of additional total transport fuel consumption, while the additional used agricultural land is 30%. For example, Bulgaria and Romania have almost 0.7 ha per inhabitant, compared to 0.4 ha in the average of EU-25. Hence, producing required feedstock internally becomes easier. In general, feedstock availability is directly related to land availability. Therefore, land availability seems to be an important and critical factor, affecting the feedstock cost. In addition, the yield and quality problem concerning land needs to be put straight from the beginning.

The EU-25 energy consumption for transport purposes is estimated to be around 321 Mtoe. Reaching the 2003/30/EC Directive target requires to bring about 18.46 Mtoe (5.75%) on biofuels. Making the hypothesis that the share of biodiesel to bioethanol remains as 70% biodiesel:30% bioethanol, it means that 4.7 Mha and 9.3 Mha will be required for raw material for bioethanol and biodiesel, respectively (wheat and rapeseed). Taking into account that bioethanol raw material is currently cultivated on 54.9 Mha in the EU-25, the estimated required 4.7 Mha represents less than 10% of this area. Hence, feedstock availability for the production of bioethanol should not be a problem.

Candidate feedstock for biodiesel production (rapeseed and sunflower) is currently cultivated on 6.4 Mha in the EU-25. The estimated required 9.3 Mha for rapeseed to biodiesel production represents nearly 150% of the current cultivated area for these crops. Although this does not mean that achieving the 2010 target is unfeasible, it will require a substantial change in production patterns and sufficient suitable land to be made available [12].

Feedstock availability for biodiesel (rapeseed and sunflower) seems much more limited than for sugar beet and wheat. In fact, in 2010, none of the EU-15 countries would be in a position to export biodiesel-related fuel crop, while some of the new member states would have some surplus potential.

Actually, there is feedstock availability for biodiesel and bioethanol in the Eastern European countries, as shown in Table 2. The specific annual yield of each raw material per hectare of cultivated area differs significantly from one country to the other, depending on various parameters, such as climate, soil, etc. Tables 3 and 4 show the specific annual yield of each raw material for biodiesel and bioethanol production, respectively, as well as the required land in order to comply with the 5.75% target, if this target is fully covered by the specific fuel.

Among the most promising countries investigated concerning biofuel feedstock production are Poland and Romania. More specifically, in Poland, the production of rapeseed increased sharply from 0.7 in 2003 to 1.25 million tonnes in 2004. Accordingly, Romania seems to have the largest currently unexplored feasible reserves of land to

Table 2
Feedstock availability for producing biofuels in Eastern European countries [10]

Country	Feedstock for biodiesel		Feedstock for bioethanol			
	Rapeseed	Sunflower	Wheat	Sugar beet	Maize	Potatoes
Bulgaria	H	H	H	H	L	L
Czech Republic	H	L	H	L	L	L
Estonia	H	L	L	L	L	L
Hungary	H	L	H	L	L	L
Latvia	H	L	H	L	L	L
Lithuania	H	L	H	L	L	L
Poland	H	L	L	L	L	H
Romania	H	H	H	H	H	L
Slovak Republic	H	L	L	L	L	L
Slovenia	H	L	L	L	L	L

H, significant potential availability; L, low potential availability for biofuel production.

Table 3
Potential bioethanol yields from common wheat and sugar beet in Eastern European EU member states along with the land required

Country	Common wheat		Sugar beet	
	L/ha [13]	% of the total area	L/ha [13]	% of the total area
Czech Republic	1568	5.66	4982	1.78
Estonia	659	3.03	–	–
Hungary	1365	4.24	N.A.	–
Lithuania	1050	2.56	2964	0.91
Latvia	908	1.92	3036	0.57
Poland	1215	3.57	3555	1.22
Slovenia	1330	6.55	4040	2.15
Slovakia	1360	3.41	3486	1.34

Table 4
Potential biodiesel yields from rapeseed and sunflower in Eastern European EU member states along with the land required

Country	Rapeseed		Sunflower	
	L/ha [13]	% of the total area	L/ha [13]	% of the total area
Czech Republic	1105	5.15	961	5.96
Estonia	536	2.45	–	–
Hungary	N.A.	–	770	4.86
Lithuania	662	2.66	–	–
Latvia	627	1.76	–	–
Poland	923	3.03	–	–
Slovenia	607	9.29	777	7.19
Slovakia	1105	2.72	961	3.14

increase the overall biofuel output. In Romania, in 2004, almost all of 100,000 tonnes of rapeseed, 70,000 tonnes of sunflower and 408,000 tonnes of sunflower seeds were exported.

5. Issues on biofuel production, distribution and consumption

Currently, only Czech Republic (biodiesel) and Poland (bioethanol) have some experience in producing relatively large volumes of biofuels. However, many Eastern European countries have the tradition and experience in the process industry, which can be exploited to produce biofuels. On the other hand, there are many investment opportunities in these countries for the implementation of small-scale units for biofuel production.

Information concerning production capacity and real production quantities differs between various sources and the data are not validated. Figs. 3 and 4 provide an indication of biofuel production in selected countries.

According to available information, in many Eastern European countries, distribution of biofuels is covered by companies not specialized in biofuel transport. The main reason of this situation is that there is not an established biofuel market in these countries.

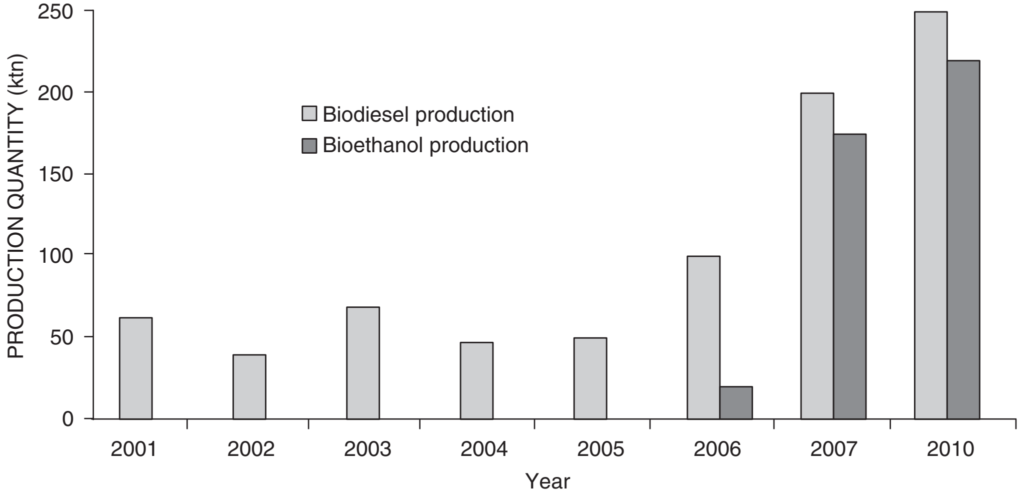


Fig. 3. Czech Republic: current biofuels production and prospects [10].

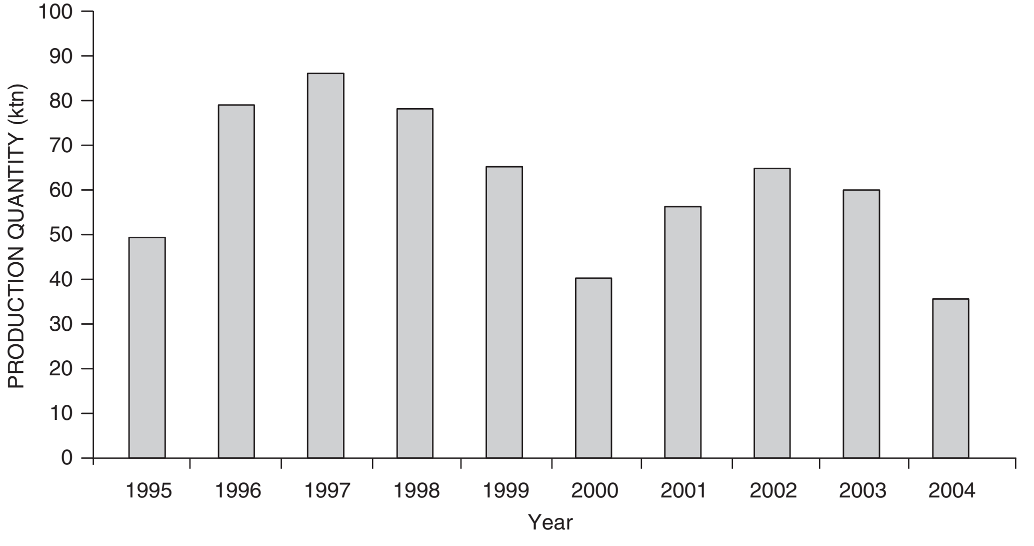


Fig. 4. Poland: bioethanol production [10].

In parallel, the domestic consumption of biofuels is lagging, mainly due to economic barriers, lack of legislative and regulatory framework and poor infrastructure. However, following the EU regulations, a market will be formed in these countries, e.g., via obligatory minimum requirements on biofuel content in all fuels. Table 5 shows the minimum target for biofuels in Eastern European countries, set by the government of each country.

Fuel consumption in the transportation sector is expected to increase significantly during the next years. Fig. 5 shows the final energy demand in the transport sector for the period 1990–2020 in Eastern European countries.

Table 5
Biofuel target for Eastern European EU members for 2005 [8]

Country	Biofuel target for 2005, minimum %
Czech republic	3.7 (2006)
Estonia	0
Hungary	0.4–0.6
Latvia	2
Lithuania	2
Poland	0.5
Slovakia	2
Slovenia	3

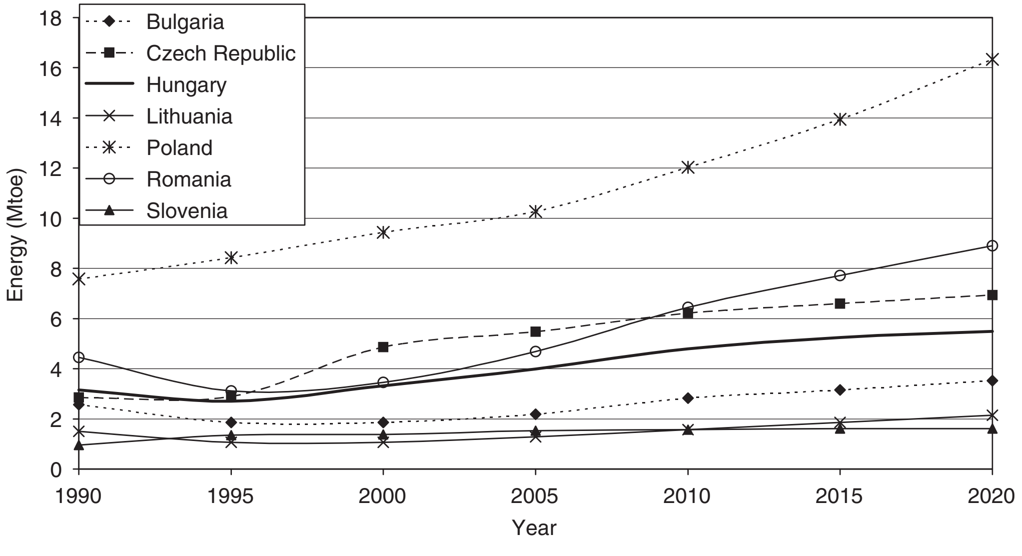


Fig. 5. Final energy demand in the transport sector in Eastern European countries [11].

The distribution of biodiesel by delivering it to the conventional refineries—where it is blended with 5% to fossil fuels—avoids the building of a separate and costly infrastructure, and big volumes can enter the market immediately. However, this has the drawback that the fuel does not become recognizable by the consumers and its advantages are applied only in a diluted way.

Promotion and use of biofuels in Eastern European countries depends on various critical factors, including infrastructure, legislation and policy. In the countries under consideration this is even more difficult, mainly because—at the moment—they are lagging in technology and infrastructure in general. Country-specific situation is summarized in Section 7. In general, the most important factors affecting biofuel implementation are as follows:

- Favourable taxation (tax reduction or tax exemption on biofuels).
- Support of agriculture as well as the mentality of the farmers.

- Political, financial and legislative framework.
- Direct investment in biofuel technology and biofuel market.
- Infrastructure (roads, fuelling stations, etc.).
- Existence of major players that have invested in technology, have the resources to enter in the market and have also marketing experience.
- Ability to deploy a strategy and carry it out with continuity for a long time is a criterion of success, since most incentive actions need time to become prosperous.
- Automotive industry and car technology play a critical role in biofuel implementation. Most car manufacturers allow only standard-grade fuel in their vehicle models, generally with a maximum 5% of biofuels (e.g., EN590). This can be acceptable in the first phase to start the market, but to reach the 5.75% target of the EU in 2010, higher blends or the use of pure biofuels is necessary.
- Car maintenance will also become a critical factor in successful biofuel implementation, since proper training and infrastructure will be required.

6. Biofuel economics

Generally speaking, biofuel production cost is currently higher than that of the classic fuels; sometimes the critical factor is the raw material cost. There are also significant costs of marketing, distribution and service.

Almost 80% of the total production cost resides on the raw material cost. As already mentioned, at the moment, biofuels are about 2.3 times more expensive than fossil fuels. For bioethanol, this figure ranges between 2.6 and 2.8 as compared to petrol. However, cost comparisons are highly dependent on the fluctuations in the international market for crude oil and refined products and in biofuel feedstock. On the other hand, the continuous efforts for the increase in the raw material yields as well as the advances in production technologies will make this cost relationship more favourable for biofuels.

At the moment, only 20% of the total rapeseed grown in the EU is used for biodiesel production and this illustrates the fact that energy crops have other economical uses. Production costs of biofuels vary and are dependent on the prices of raw materials, the production method, the extent of refining undertaken and the supplementary utilization of by-products and waste. In the general case, the biofuel production cost in the Eastern European countries is not cheaper than in the rest of the EU. Figs. 6 and 7 indicate the cost of energy crops for biodiesel and bioethanol, respectively, whereas Table 6 presents the current production costs of biofuels (in €/L).

7. Current status in selected countries

In this section, a summary of the current status concerning biofuel implementation in the countries under consideration is given. The main issues being highlighted in the description and summarized in Table 7 are feedstock availability, production base, use and prospects of biofuels in the selected countries.

As far as raw materials for biofuels are concerned, Czech Republic has a significant experience, especially in the production of rapeseeds for rape methyl ester. In Poland, the key feedstock for bioethanol production is potato and cereals and it is cheaper than producing bioethanol from wheat and sugar beet. Lithuania has long traditions in growing crops and the climatic conditions are also favourable for the cultivation of grains.

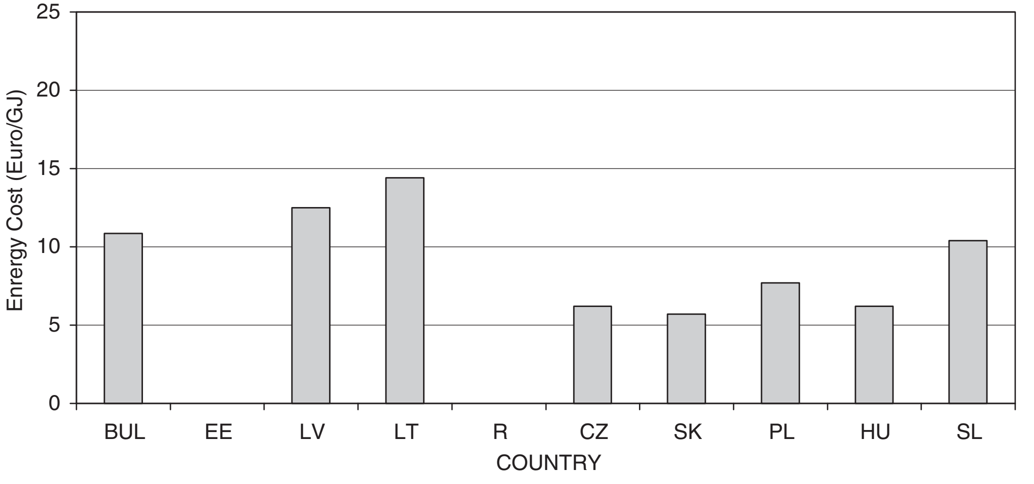


Fig. 6. Cost of energy crops for biodiesel in the new EU countries [8].

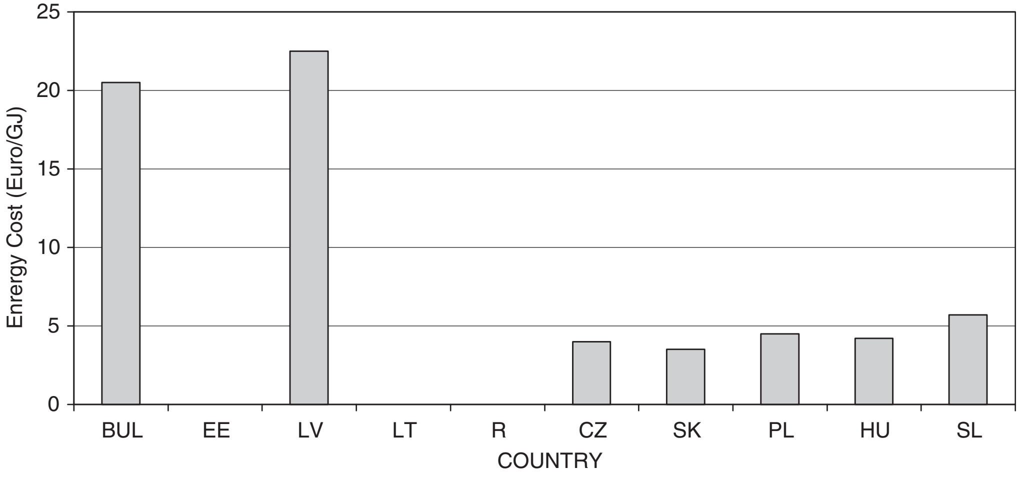


Fig. 7. Cost of energy crops for bioethanol in the new EU countries [8].

Approximately 10–15% of Lithuania's land could be used for the cultivation of crops for energy needs.

Romania has a significant potential for production of bioethanol from sweet sorghum and biodiesel from rape oil and sunflower oil. It also has very good prospects as a net exporter within the EU. Bulgaria also has significant potential to produce biofuels especially made from wheat (bioethanol) and sunflower (biodiesel), also being favoured by the weather conditions.

Czech Republic is a pioneer country in biofuel production. It is the leader in the number of production sites, with 16 biodiesel plants. Boost in biofuel production is expected for 2007 in Czech Republic.

Table 6
Indicative production cost (€/L) of biofuels in selected Eastern European countries [8]

Country	Biodiesel	Bioethanol	Remark
Bulgaria	–	0.36	Average 1996–2000 for non-automotive purposes
Latvia	0.42	0.56	Prevailing figures
Lithuania	0.41	0.57	Prevailing figures
Hungary	0.65	–	Prevailing figure
Poland	0.75	0.60	BD—cost in 2002, BE—price in 2000
Slovakia	0.70	–	Price in 2002
EU-15	0.56	0.36–0.54	Average figures

Poland is the only country among the new member states that has already developed the biofuel sector to a significant extent. It is a net biofuel exporter. Biofuel production in Poland is favoured by the availability of large agricultural areas, ideal for growing oil seed rape, and good climatic conditions for rapeseeds and potato.

Lithuania has limited domestic production capacity for biofuels. Two plants are in pilot operation, one for bioethanol and the other for biodiesel. An important project in the country related to the production of biofuels is the restructuring of the Lithuanian oil refinery AB Mazeikiu Nafta.

Romania is considered to be a promising country as a clear net contributor to bioethanol availability. It also becomes the second biggest producer of biodiesel, exploiting its good expertise in research, fuel production and processing.

As far as biofuel use is concerned, in Czech Republic, conditions for placing pure biodiesel on the motor fuel market have been created in accordance with technical measures and amendments made to legislation currently in force. The return excise tax amounts to 100% for bioethanol used at car petrol production. There is a lower excise duty on blended fuel or biodiesel, which means that biodiesel incorporated in a fuel blend carries zero excise duty.

Currently, biofuels are free from excise tax in Poland but other regulatory, legislative and economic barriers are identified. This includes the lack or the vagueness of legislation for fiscal support mechanisms and standards. Practically, the major obstacles towards the development of liquid biofuels are the economic conditions.

Lithuania has a significant production base that could properly be exploited to produce biofuels. The legal basis for the implementation of the biofuels Directive has been prepared. Mandatory targets have been established in the country from the end of December 2005. More specifically, two legal acts on the mandatory use of biofuel for transport (as a percentage in the conventional fuels) have been adopted.

Romania has a significant national market. There is no legislation or any other measure in place yet for biofuel promotion. In Bulgaria, the serious deficit of infrastructure and mentality in general for biofuel promotion (tests, standards, investments, etc.) as well as the lack of clear government policy and any relevant legislation make the development of the domestic market difficult.

Finally, for the two candidate countries, i.e Bulgaria and Romania, the prospects for biofuel development are very good. For Romania, the export will be the main driving force for biofuel production, while the internal market will probably need several years to be developed. Biofuels might prove to be a good opportunity for the future development of

Table 7
Summary of current status and future prospects of biofuels

	Czech Republic	Poland	Lithuania	Hungary	Romania	Bulgaria
Biofuel resource availability	Rapeseed availability	Extensive availability of raw materials	Long traditions and good climatic conditions for growing crops	Limited domestic biomass resources	Sweet sorghum, rapeseed oil and sunflower oil	Sunflower, wheat, rapeseed
Biofuel production	Significant experience in RME production, leader in the number of production sites	Considerable biofuel manufacturing base	Limited production capacity	Small quantities	Limited	No significant production yet
Legislation	Subsidies for rapeseed	Unclear unstable legal support framework	Legal basis has been prepared	Some progress has been made	Not prepared yet	Lack of legislation
Measures and incentives	Low excise duty on blended fuel/ biodiesel	No excise tax, major obstacles are the economic conditions	Mandatory targets have been established	Refund of excise tax on biodiesel and bioethanol	No excise tax for biodiesel	No tax reduction, lack of government policy
Prospects for biofuel development	Very good	Very good, largest biodiesel manufacturer	Restructuring of a big refinery will increase production	Efforts required	Very good because of raw materials and biofuels production	Very good, favourable climate conditions and good tradition
Prospects for biofuel exports	Very good, domestic market will be developed	Very good, already a net exporter	Depends on domestic demand and market prices	Not enough resources	Driving forces for raw materials and biofuel production development	Domestic market is unready, lack of infrastructure

the Romanian agriculture and process industry. In parallel, the lack of local investment funds and local investment support for biodiesel plants in Bulgaria creates the possibility for joint ventures and consequent export. In fact, the country has very good prospects to become a significant biofuel exporter in Europe.

8. Conclusions

The accession of Eastern European countries has various positive effects as far as the biofuel implementation is concerned for the countries themselves and for the EU in general. Indicatively, the effects include the following:

- The utilization of set-aside and underutilized land by the agricultural sector increase the employment potential.
- There may be small-scale capital investments for the establishment of production units and, hence, the reduction in transportation costs.
- Biofuels may use the existing distribution facilities, unlike any other sustainable transport fuel.

The present work has led to some interesting results concerning the prospects of biofuels in Eastern Europe. As a matter of fact, there is not a unique conclusion concerning the potential of these countries in the overall biofuel supply chain in the EU. It is without doubt that these countries have significant land availability, much more than the average of the rest of EU. It is also a fact that these countries possess significant production base and experience in land cultivation. Therefore, the prospects related to the feedstock and biofuel production are good. Some of these countries are in fact already leaders in biofuel production.

In parallel, the domestic consumption of biofuels is lagging, mainly due to economic barriers, lack of legislative and regulatory framework and poor infrastructure. This supports their prospects as raw material exporters. However, following the EU regulations, a market will certainly be formed in these countries, e.g., via obligatory minimum requirements on biofuel content in all fuels.

In conclusion, the significance of the recently joined Eastern European countries is not only their land availability or production capacity. The most interesting issue is that the EU market is now much larger, the supply chain is more extended, the opportunities for rural development are significant and small-scale production investments are more attractive.

References

[1] Ericsson K, Nilsson LJ. Assessment of the potential biomass supply in Europe using a resource focused approach. Biomass Bioenergy 2006;30:1–15.
[2] Korma E, Panoutsou K, Kaldellis JK, Tsoutsos Th. Plant biomass management-raw material analysis. NTUA-RENES Unet, In: Proceedings of the second national conference for the Application of Renewable Energy Sources, Athens, Greece; 2001. p. 468–73.
[3] Hamelinck CN, Faaij APC. Outlook for advanced fiofuels. Energy Policy; 2006. Online available at www.ScienceDirect.com.
[4] Faaij APC. Bio-energy in Europe: changing technology choices. Energy Policy 2006;34(3):322–42.

[5] Kahraman B. Biodiesel as an alternative motor fuel: production and policies in the European Union. Renew Sustain Energy Rev; 2005. Online available at http://www.ScienceDirect.com.
[6] Sakkas Th, Kaldelli El, Murphy JD, Kaldellis JK. Ethanol production for the Greek transportation sector using municipal solid wastes. Techno-economic and Environmental Analysis. In: Proceedings of the first national conference of Chemical Engineers on Alternative Fuels, January 2005, Athens, Greece.
[7] Reiche D. Renewable energies in the EU-accession states. Energy Policy 2006;34(3):365–75.
[8] IPTS, JRC. Biofuel production potential of EU candidate countries. Report EUR 20835 EN; 2003. Available at http://www.europarl.eu.int/stoa/ta/renewable_energies/biomass/biofuel(ipts).pdf (accessed February 2006).
[9] Nikolaou A, Remrova M, Jeliazkov I. Biomass availability in Europe, lot 5: bioenergy's role in the EU energy market. Centre for Renewable Energy Sources, BTG Czech Republic s.r.o, ESD Bulgaria; 2003. Online available at www.europa.eu.int/comm/energy/res/sectors/doc/bioenergy/cres_final_report_annex.pdf (accessed February 2006).
[10] Kaldellis JK, Kondili E, Papapostolou C, Spyropoulos G. Biofuels in Eastern Europe. Report number PREMIA TREN/04/FP6EN/S07.31083/503081; 2005.
[11] European Union. European energy and transport—trends to 2030, Summary energy balances and indicators, Appendix 2; 2006. Online available at http://europa.eu.int/comm/dgs/energy_transport/figures/trends_2030/appendix2_en.pdf (accessed February 2006).
[12] PricewaterhouseCoopers. Reference framework for the development of policy measures. Online available at http://www.klimaat.be/pdfs/Biofuels_1.pdf (accessed February 2006).
[13] European Biomass Industry Association (EUBIA). Online available at http://www.eubia.org (accessed February 2006).